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A QoS-aware Mobility Management Framework in All-IP Networks

ABSTRACT

All-IP networks are becoming increased interest for commercial mobile networks. These networks connect the various communication networks through a common IP core. A main challenge in these networks is how to deliver **Q**uality **o**f **S**ervice (QoS) guarantees for real-time services while **M**obile **N**ode (MN) moves from a certain point of attachment to another.

In this paper, we propose a new QoS-aware mobility management framework in IP-based networks. In this framework we integrate the **M**obile **I**P **F**ast **A**uthentication **P**rotocol (MIFA) with the **R**e**S**source reser**V**ation **P**rotocol (RSVP) to support a fast QoS re-reservation during and after the movement.

1. INTRODUCTION

The development in the last years is towards All-IP networks and real-time services in wireless mobile networks. The main challenge in such networks is how to deliver QoS guarantees for real-time services while MNs move from a certain point of attachment to another. Mobility has a big impact on the QoS parameters (reduce the packet loss, minimize the resource reservation delay resulting from Handoff, high bandwidth, delay jitter).

Mobile **IP** (MIP) version 4 [1], [2] and version 6 [3] are the standard solutions for mobility management in IP-based systems. MIP adds two specific entities to the network which are **H**ome **A**gent (HA) and **F**oreign **A**gent / **A**ccess **R**outer (FA/AR). The MN is provided with two IP addresses. The first one is a permanent address, called home address. The second one is a temporary address, called **C**are **o**f **A**ddress (CoA). The CoA depends on the foreign network the MN visits. The HA is responsible for the management and authentication of the MN every time it moves from one FA to another. This results in extra latency for the communication, especially when the HA is far away from the FA.

MIFA [4] is a mobility management protocol developed to avoid the problems of Mobile IP and to achieve fast and smooth handoff. Therefore a FA manages a set of neighboring FAs to which the MN may move to in the future. This set is called **L**ayer **3**-**F**requent **H**andoff **R**egion (L3FHR). An L3FHRs can be built statically or dynamically. However MIFA does not support any QoS guarantee. RSVP [5] is an IntServ mechanism [6] which enables Internet applications to obtain differing QoS for their data flows. The sender sends a PATH message along a path of routers. Each router records the request information in a soft state and forwards the PATH message to the next router. When the PATH message reaches to the receiver it reserves the required resources and sends a RESV message on the same path back towards the sender. Each router on the path reserves the requested resources when receiving the RESV message. Although, RSVP is a good solution to reserve resources it does not notice the mobility of MNs.

Therefore, it is necessary to integrate mobility management and QoS reservation to achieve a suitable solution for future IP-based mobile system.

Our proposal is called **Q**oS-enabled **M**obile **I**P Fast **A**uthentication protocol (QoMIFA). In our approach we extend RSVP by MIFA. We add a new object, called ***mobility object***, to RSVP messages. This object encapsulates [7] the mobility information required to perform the procedures of MIFA. The previous FA reserves resources between previous FA and new FA to forward the packets during and after a handoff until the new reservation between the HA and the new FA is performed. After that the old resources will be released. Thus, the time needed to exchange RSVP messages and to reserve resources between the HA and the new FA is hidden from the application. Additionally, QoMIFA only needs to change RSVP in the FA and in the HA.

The paper is organized as follows: Section 2 describes the related work. After that we describe our proposal details in Section 3. Finally, we conclude with the main results and the future work in Section 4.

2. RELATED WORK

There are various solutions proposed to support the coupling between QoS and mobility [8], [9], [10]. These solutions try to restrict the impact of mobility as local as possible, and thus separate between intra-domain and inter-domain reservation. These approaches naturally suffer from several problems directly affecting the performance e.g. they have to support hierarchical topologies of the networks, as well as GFA is still a point of failure. There are three kinds of coupling between QoS and Micro mobility:

1. No coupling: each protocol works independently,

2. Loose coupling: any changes or event occurring in one of them produces some action in the other.

3. Hard coupling: The information for protocols (QoS and mobility) is conveyed overall, either as a new protocol managing QoS and mobility or as a protocol extension. ''QoS and Micro mobility Coupling '' [8] this work proposes the integration between RSVP and hierarchical MIP in order to support QoS and Micro mobility. This concept depends on loose coupling. The idea is to make QoS mechanisms aware of changes at the point of attachment of MNs. When a MN performs a handoff in intra-domain, the MN repairs the reservation only in the place where the route changes in order to establish faster end-to-end reservation. The states in the **G**ate **FA** (GFA), the FA and the routers between them will be assigned to a value equal to the remaining lifetime of the previous path. When the lifetime expires, the end-to-end reservation will be updated. However, this approach suffers from long renewing time for RSVP session when the MN changes its domain to another i.e. the latency until the new route is established.

''**H**ierarchical **M**obile **RSVP** (HMRSVP)'' [9] integrates RSVP with the Mobile IP regional registration protocol, when a MN visits FA. In order to establish the session between MN-**C**orrespondent **N**ode (CN) it sends a PATH message to the GFA, which forwards it to the CN. Then the CN replies with a RESV message towards the MN. When a MN moves to another FA within the domain, which belongs to the same GFA, the MN sends a PATH message only to GFA. The GFA sends a RESV message to the MN. When a MN wants to change the GFA (inter-domain), it initiates a passive reservation at the CN while it passes the overlapped area between the two domains. This reservation is turned into an active reservation as soon as the MN is registered in the new domain. However, this proposal leads to problems from long duration during the set up of the new session, when the MN doesn't make a passive reservation within the overlapped area.

''Resource Reservation with Pointer Forwarding Schemes for the Mobile RSVP'' [10] explains three advance resource reservation schemes for HMRSVP in relation to localize the passive reservation messages. First HMRSVP performs a resource reservation in advance on all the branches, second HMRSVP accomplishes resource reservations in advance in the two neighboring FAs. Only as third, HMRSVP makes advance resource reservations in advance on the forward one-step path from an MN along the forwarding pointer chains. Consequently, the third case is the best solution (pointer forwarding scheme), the renewing time is reduced through the addition of new

RSVP sessions. This scheme also could significantly decrease the reservation cost when a mobile host moves locally.

However, this approach may cause an excessive long RSVP path in the case of several handoffs. The router along this path is in danger to be overcrowded.

These applications try to solve the interworking problem between RSVP and mobility e.g. they performs a local reservation as the MN moves inside the domain. However, they still depend on hierarchical topologies of the networks. Here we explain a new application in this paper which reduces the delay re-reservation of resources during and after the handoff and needs to change RSVP in the FA, HA and MN, only. Also it provides a solution for both intra-and inter-domain mobility.

3. QoS ENABLED MOBILE IP FAST AUTHENTICATION (QoMIFA)

QoMIFA is a robust protocol and achieves a fast and smooth handover along with fast re-reservation of resources. It extends RSVP through the integration of a new object called mobility object. This object encapsulates the MIFA messages. In the following we discuss the reservation process in details.

a) Phase 1(Initial Registration)

In Figure1 the **M**essage **S**equence **C**harts (MSC) for this phase are depicted. A MN uses the standard procedures of MIP to register its CoA with the HA. However, the MN has to inform the FA and the HA that it wants to use MIFA in the next registration, see [4]. As a response the HA initiates a security association between the HA and the FA ($K1_{FA\text{-}HA}$) on one side and between the MN and the FA ($K1_{MN\text{-}FA}$) on the other side. The FA creates the keys, generates two random variables R_1, R_2, generates another key ($K2_{MN\text{-}FA}$), encrypts $K2_{MN\text{-}FA}$ with $K1_{MN\text{-}FA}$, adds R_1, R_2 and the encrypted $K2_{MN\text{-}FA}$ to the **Reg**istration **Reply**(Reg_Reply) message, authenticates the new message with $K1_{MN\text{-}FA}$ and sends it to the MN. $K2_{MN\text{-}FA}$ is the security association between the MN and the FAs in the L3-FHR, to which the current FA belongs to.

After that, the current FA sends a **M**ove **P**robability **Not**ification (M_P_Not) message to the HA. The message contains two random variables R_1, R_2 and a newly generated security association between the HA and all of the FAs in the L3-FHR ($K2_{FA\text{-}HA}$), to which the current FA belongs to. This key is encrypted with $K1_{FA\text{-}HA}$, which has been generated during the initial registration. Then HA sends a **M**ove **P**robability **Ack**nowledgement (M_P_Ack) message to the current FA. This message contains all the information needed to authenticate and to authorize the MN in the next registration.

The PATH message including the mobility object is sent to each FA in the L3-FHR. The mobility object contains the M_P_Not message, see [4]. In order to use MIFA in the next registration, the authentication information has to be sent to the FAs in the L3-FHR. The neighbor FAs will record MIFA information and the path states in a soft state and send a RESV message to the current FA. However, this message will reserve a zero bandwidth. This reservation is done in order to distribute the information to the neighbor FAs and to record path states without making passive reservations and thus without wasting resources.

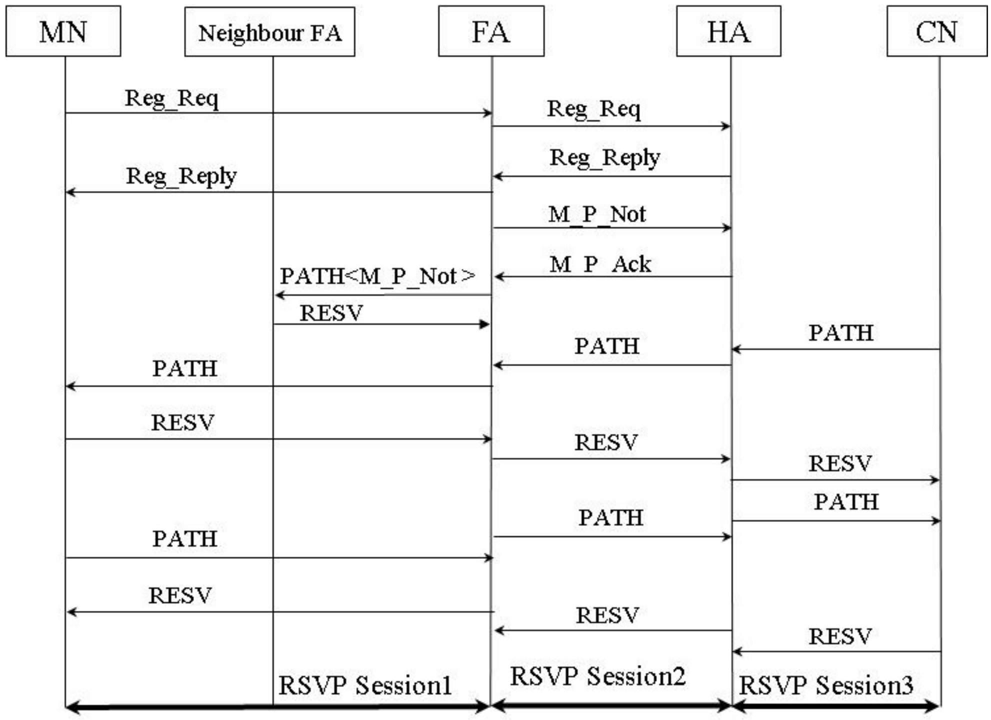

Figure 1: Initial registration and reservation

b) Phase 2 (Initial Reservation)

In phase 2 it is explained, how the CN is forwarding data to the MN.

In Figure 1, the CN sends a PATH message to the MN's home address. This message is intercepted by the HA, which forwards a new PATH message to the current FA. When the FA receives this message, it sends another PATH message to the MN. MN replies with a RESV message to the current FA, when it receives the PATH message. The FA then transmits a new RESV message towards the HA in the same way than for the PATH message. After receiving this message the HA in turn sends a new RESV message to the CN. When the RESV message is received this means that a new RSVP session between CN and MN is established in downlink.

In the same way an uplink RSVP sessions is established. The MN sends a PATH message to the current FA, which in turn creates another PATH message and sends it to the HA. When the HA receives this message, it intercepts this message and sends another PATH message to the CN. RESV messages are sent then on the way to the MN. As a result, the bidirectional RSVP session between the CN and the MN is split into three bidirectional RSVP sessions. RSVP Session1 is between the CN and the HA, RSVP Session2 is between the HA and the current FA and the last one - RSVP Session3 - is on the wireless link. Depending on mapping information of the RSVP Sessions1 and 2 should be mapped within the HA, while the FA has to map between the Sessions 2 and 3. The mapping information can be extracted from the end-to-end PATH messages, the **Flow spec**ification (flowspec) from the end-to-end RESV message.

c) Phase 3 (handoff procedure)

Figure 2 explains the MSCs when the MN performs a handoff. When the MN moves to a new FA, which belongs to the L3-FHR of the previous FA, it sends a PATH message to this new FA. This message contains the mobility object. The **Reg**istration **Req**uest (Reg_Req) message is placed in this mobility object. The new FA authenticates the MN according to the MIFA procedures. If this succeeds, it sends the same PATH message to the previous FA containing the P_FA_Not as a mobility object. When the previous FA receives this PATH message with the **P**revious **FA Not**ification (P_FA_Not), it reserves resources in uplink for the MN and sends a RESV message with the **P**revious **FA Ack**nowledgement (P_FA_Ack) in the mobility object. The new FA forwards it to the MN with the Reg_Reply encapsulated in the mobility object, after the new FA receives RESV message. The previous FA sends a PATH message without a mobility object to the new FA. When it receives the PATH message, it is forwarded to the MN too.

The MN checks the authentication and the MIFA information is recorded in the Reg_Reply. After that, when the MN receives the PATH message it responds by sending a standard RESV message on the same way.

As a result, a bidirectional RSVP Session4 is established from the previous FA to the MN through the new FA. Periodic refresh messages are exchanged to update the mobility information in all RSVP routers along the remaining path. Now, the packets are exchanged between the CN and the MN through the old FA. After that the MN must reserve resources at the CN through the new FA. In order to do that in uplink the MN sends a PATH message to the new FA without the mobility object. The new FA sends then another PATH message to the HA with the HA Notification (HA_Not)in the mobility object. The HA_Not is used to inform the HA about the new binding. The HA checks the information in the HA_Not. After that, it reserves the required resources and sends a

RESV message to the new FA with a mobility object containing the HA Acknowledgement (HA_Ack). The HA_Ack contains all MIFA information necessary for the next registration. The new FA then sends a new RESV message to MN. Additionally, in order to reserve a downlink RSVP sessions between the HA and the MN, the HA sends a standard PATH message to the new FA. The new FA sends another PATH message to the MN, the MN answers with a RESV message to the new FA, which sends the RESV message to the HA. When the HA receives this message, two new bidirectional RSVP sessions are established. One is a RSVP Session5 from the HA to the new FA. The other RSVP Session6 is from the new FA to the MN. To ensure correct routing refresh messages are exchanged to update the mobility information in all RSVP routers on the path between the CN and the HA.

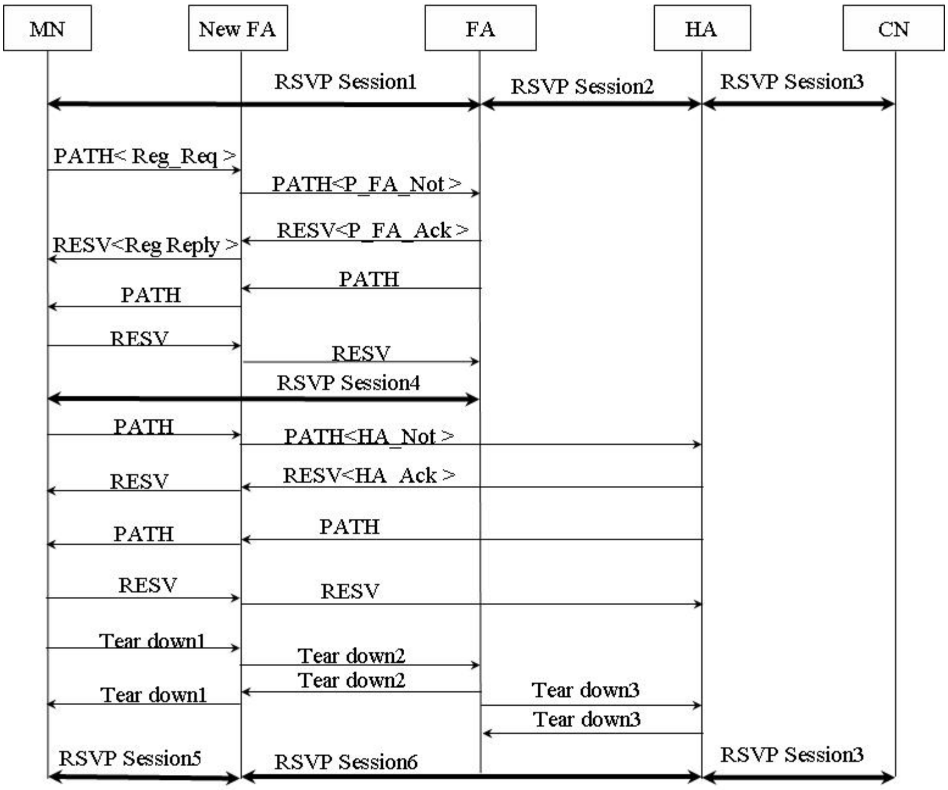

Figure 2: Handoff in QoMIFA

At this point there is no need for the old reservations (Sessions 1, 2 and 4), thus teardown messages are sent to release these sessions.

As result, the resources are fast reserved and released. The time required to resume receiving and transmitting of data with QoS reservations is minimized without introducing new entities to the network and without requiring a hierarchical network architecture.

4. CONCLUSION

In this paper, we have integrated MIFA with RSVP in order to support a fast QoS re-reservation during and after the handoff and the approaches reduce the signaling overhead by adding a new object, called mobility object, to RSVP messages. This approach has one important advantage, the time needed to exchange RSVP messages and to reserve resources between the HA and the new FA is hidden from the application. Additionally, QoMIFA needs to change the RSVP implementation in the FA and in the HA only, the CN can use the old reservations, while the new re-reservations are in progress. QoMIFA is a robust protocol and achieves a fast and smooth handover along with fast re-reservation of resources.

We are now working on an implementation within the network simulator-2 (ns-2).

References:

[1] C. E. Perkins, “MOBILE IP - Design Principles and Practices”, January, 1998.

[2] C. Perkins, Ed, “IP Mobility Support for IPv4”, RFC: 3344, August, 2002.

[3] D. Johnson, C. Perkins, J. Arkko, “Mobility Support in IPv6”, RFC 3775, October, 2003.

[4] A.Diab, A.Mitschele-Thiel, R. Böringer,“Extension of Mobile IP for Fast Authentication”, 46. Internationales Wissenschaftliches Kolloquium Technische Universität Ilmenau 27.-30. Sep. 2004.

[5] R.Braden, L.Zhang, S.Berson, S.Herzog, S.Jamin, “Resource ReSerVation Protocol(RSVP)Version1Functional Specification”, Internet Request For Comments RFC 2205 Sep.1997.

[6] R.Braden, D.Clark, S. Shenker, “Integrated Services in the Internet Architecture”, an Overview, RFC 1633 ISI, MIT and PARC, June 1994.

[7] R. Böringer, A. Saeed, A. Diab, A. Mitschele-Thiel, M. Schneider, "I-MPLS: A Transparent Micro-Mobility-enabled MPLS Framework", 11th European Wireless 2005, Cyprus, April 10-13, 2005.

[8] L.Galindo-Sánchez , P.Ruiz-Martínez, “QoS and Micro mobility Coupling”, Vol. VI, issue No. 2, April 2005.

[9] C.-C. Tseng et al., “HMRSVP: A Hierarchical Mobile RSVP Prtocol”,Proc.Int’l. Conf. Distrib. Comp. Sys. Wksp., Apr. 2002.

[10] G.-C. Lee, T.-P. Wang and C.-C. Tseng, “Resource Reservation with Pointer Forwarding Schemes for the Mobile RSVP” IEEE Commun. Lett., vol. 5, no.7, July 2001.

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